DRAFT
Geology: Existing Condition and Environmental Consequences
Turkey Cove Vegetation Management Project
Lee County
Clinch Ranger District
George Washington & Jefferson National Forests

Prepared by: Thomas Collins, Forest Geologist

October 1, 2018

Geology

Scope of the Analysis:

The geographic bounds for this analysis are the project area.

Existing conditions

The project area in Lee and Wise Counties is located on the southeast slope of Wallen Ridge and northern slope of Powell Mountain which are underlain by folded Paleozoic sedimentary bedrock and derived surficial deposits such as colluvium and soils. The geologic map of the Big Stone Gap Quadrangle (Miller, R.L., 1965) covers most of the project area. The geologic map of the Keokee quadrangle (Miller, R.L., and Roen, J.B., 1971) covers a small southwest corner of the project area.

Project activities would be conducted on the southeast slope of Wallen Ridge. The upper slopes of Wallen Ridge are underlain mainly by sandstone and some shale of Poor Valley Ridge Member of the Clinch Sandstone Formation. The lower slopes of Wallen Ridge are underlain mainly by shale and siltstone and some sandstone and hematite iron ore beds of the Clinton Formation. The lowest slopes of Wallen Ridge along the North Fork of Clinch River and Lovelady Creek are underlain in some stretches by narrow bands of Hancock Limestone.

The landforms in the project area are a result of the interaction of surface geologic processes (such as weathering, mass wasting, stream incision, flooding, erosion, transport and deposition of sediment) with the underlying geologic formations and geologic structures (such as dip slopes). The southeast slope of Wallen Ridge is a dip slope in which the downslope inclination of the sedimentary bedrock layers controls or influences to the slope (inclination) of the ground surface. The upper slopes of Wallen Ridge underlain mainly by the Poor Valley Ridge sandstone is a relatively uniform slope with U-shaped drainages or swales. In contrast, the lower slopes of Wallen Ridge underlain mainly by shale and siltstone of the Clinton Formation have incised steep-sided V-shaped drainages.

Slope stability and Landslides

The geologic process of mass wasting (landslides activity) is part of the natural disturbance regime in the project area (Outerbridge, 1982; Wooten et.al., 2015). Various types of landslides (such as rockslides, slumps, rockfalls) occur over time throughout the southern Appalachian Highlands, but debris flows are the dominant landslide process in the southern Appalachian Highlands in Virginia and North Carolina

(Wooten et al., 2015). Debris flows are a natural landslide hazard on the steep slopes within the project area. Debris flows can travel hundreds or thousands of feet downslope. A debris flow can move down through a watershed rapidly and poses a risk to public safety, resources, and infrastructure far downslope from the slope failure source area (initiation zone). In the project area, the areas that are most susceptible to landslides, especially during storm events, are drainages (hollows) and stream banks and steep sideslopes adjacent to streams.

Human activities (construction for roads, log landings, and historic mineral activity (iron)) have altered conditions affecting slope stability in many parts of the project area. But the alterations have not resulted in significant slope instability. For example, the more than 10 miles of the Forest Service roads that span across the southeast flank of Wallen Ridge are generally stable.

Karst

The lowest slopes of Wallen Ridge along the North Fork of Clinch River and Lovelady Creek are underlain in some stretches by narrow bands of Hancock Limestone (carbonate bedrock). Field surveys conducted for this project have not found any sinkholes, limestone caves or other karst features in the area of the project. This is consistent with the 1:24,000 scale geologic maps which show most of the project area is underlain by clastic (non-carbonate) bedrock, with narrow bands of Hancock Limestone (carbonate bedrock) on the lowest slopes of Wallen Ridge along some stretches of the North Fork of Clinch River and Lovelady Creek (Miller, R.L., 1965; Miller, R.L., and Roen, J.B., 1971).

The U.S. Geological Survey produced a karst map of the U.S. (Weary and Doctor, 2014). The map delineates areas of karst or potential karst based on geologic maps of carbonate rocks at or near the land surface. Weary and Doctor (2014) state: "The extent of outcrop of soluble rocks provides a good first approximation of the distribution of karst and potential karst areas, particularly in parts of the United States with a humid climate". In Virginia the USGS karst map is based on a 1:500,000 scale state geologic map. In some areas such as the project area, the 1:500,000 scale geologic map units lump together different geologic formations only some of which are carbonate rocks. Nearly the entire project area on the 1:500,000 scale map is covered by one geologic map unit (Shrc) containing three geologic formations: Hancock, Rose Hill and Clinch Formations. The geologic map unit Shrc in the Virginia Interactive Geologic Map has shale as the primary rock type and siltstone as the secondary rock type (Virginia Division of Geology and Mineral Resources, 2018). The Hancock Limestone is not a dominant rock type in geologic map unit Shrc.

However, the USGS karst map used the geologic map unit Shrc as a karst map unit, and as a result, the USGS karst map shows nearly the entire project as karst. The more detailed map units in the 1:24,000 geologic maps show the opposite, most of the project area is clastic (non-carbonate) bedrock, with only some narrow bands of Hancock Limestone (carbonate bedrock) along the North Fork of Clinch River and Lovelady Creek borders of the project. The map of karst features by Hubbard (2001) at a 1:250,000 scale also shows most of the project area in clastic (non-carbonate) bedrock, with a narrow band of carbonate bedrock near the North Fork of Clinch River.

Environmental Consequences

Slope stability and landslides

The Proposed Action Alternative would conduct ground disturbing activities including construction of roads, log landings, and fire lines, as well as timber harvest and prescribed burns. These activities have the potential to alter conditions affecting slope stability by undercutting natural slopes or by diverting surface drainage, or by placing excavated material (fill) on natural slopes. The alteration of conditions affecting slope stability could be sufficient to lead to slope failures, such as failures of road cut-or-fill slopes or log landing cut-or-fill slopes, or slope failures in timber harvest units or fire lines.

Excavation for roads and log landings removes support from the natural slope and leaves a cut slope that is steeper than the natural slope. Excavated material is placed on the natural slope to form a fill slope. Fill slopes are composed loose excavated material, and add weight on top of the natural slope.

The construction of roads, log landings and fire lines would alter the surface and subsurface drainage in the areas of construction and in adjacent natural slopes. Changes in surface and subsurface drainage may increase pre-existing landslide hazard, and may create or contribute to failure of natural slopes. Timber harvest (tree cutting and removal) on steep slopes can alter slope stability by raising near-surface water tables and by decreasing root strength.

Potential impacts on slope stability would depend on many factors, such as the bedrock structure (orientation and distribution of bedrock fractures or discontinuities); the mass strength properties of in-place bedrock and slope deposits including soils and colluvium; rainfall quantity and intensity; presence of colluvium-filled hollows; surface and subsurface drainage including near-surface groundwater and springs.

One overarching factor and driver of potential impacts on slope stability is the steepness of the slopes where project activities would occur. Slope gradient (%) will be used as an indicator of potential for project activities to alter conditions affecting slope stability. The slopes in the southwest and northeast part of the project area are shown on two maps with slope % classification: 0--35, 35-40, 40-55, +55 (Slope Map – SW Proposed Action and Slope Map – NE Proposed Action).

The north slope of Powell Mountain has a concentration of slopes steeper than 35% within the project area. But the proposed action is on the southeast slope of Wallen Ridge, and not on the north slope of Powell Mountain. The Wallen Ridge part of the project area has slopes steeper than 35% dispersed among the slopes less than 35% along the broad southeast flank of Wallen Ridge, with the steepest slopes along the incised drainages (hollows).

Another factor in potential impacts on slope stability is the mass strength properties of the geologic formations where project activities would occur. The shales and siltstones of the Clinton Formation on the lower slopes of Wallen Ridge have less mass strength than the Poor Valley Ridge sandstone on the upper slopes of Wallen Ridge. Another factor in slope stability is geologic structure of bedrock. The southeast flank of Wallen Ridge is a dip slope in which the underlying bedrock layers control or influence the slope gradient of the ground surface. Undercutting the layers which dip (are inclined) downslope can be an adverse factor for slope stability.

The Proposed Action would alter conditions affecting slope stability. Roads and log landings would have long term effects on conditions affecting slope stability. Timber harvest and prescribed fire would have short term effects.

The alteration of conditions affecting slope stability could be sufficient to lead to slope failures, such as failures of road or landing cut-or-fill slopes, or slope failures in timber harvest units. Mitigation measures would reduce the potential for project-induced slope failures. The existing road cut-and-fill slopes and past timber harvest areas in the project are generally stable. The decades of experience with the existing road system and past timber harvest in the project area suggests the Proposed Action would be similar in potential effects on slope stability.

Mitigation measures would reduce, but not eliminate, the potential for project-induced slope failures (landslides). Debris flows are a natural landslide hazard on the steep slopes in the project area. But debris flows can also be caused by failure of fill slopes constructed for roads or log landings. Fill slopes, especially inadequately constructed and maintained fill slopes, are a potential source of debris flows in mountainous terrain (Collins 2008; Wooten et al. 2009). During Mahogany II Skyline timber sale administration in the Stony Creek watershed on the Clinch Ranger District it was determined that the planned logging system (skyline) would not work due to inadequate deflection. As a result, a poorly constructed temporary road and log landing were constructed. The July 29, 2001 and March 15, 2002 rainstorms in the Stony Creek watershed triggered debris slides/debris flows from the fill slopes of the Mahogany II log landing and the temporary road as well as from natural slopes.

Whether due to a fill slope failure or a natural slope failure, debris flows can travel hundreds or thousands of feet downslope. Where fill slopes would be constructed for roads and log landings on slopes greater than 40%, the alteration of conditions affecting slope stability may be sufficient at some sites to increase the potential for a fill slope failure, and possibly, a debris flow that would pose a risk to public safety, resources, and infrastructure downslope on National Forest land and non-Forest land.

The No Action Alternative would not add to the existing alteration of conditions affecting slope stability from past activities. The potential effects from past activities would continue, including the potential for slope failures of road or log landings, and possibly, debris flows.

Cumulative effects

The geologic process of mass wasting (landslides activity including debris flows) is part of the natural disturbance regime in the project area. Past human activities (mining; timber harvesting; roads, etc.) have altered conditions affecting slope stability in the project area, and as a result, increased the potential for slope instability. The No Action Alternative would not add incrementally to the potential slope instability from past human activities. The Proposed Action Alternative activities would add to the alteration of conditions affecting slope stability from past activities and would add incrementally to the potential slope instability from past human activities. Provided the roads, log landings, and fire line are properly constructed and maintained, the project is expected to have minor effects on slope stability. Effects are expected to be similar to effects from previous similar projects. No unique or unknown risks related to slope stability are expected to occur from this project. Considering the mitigation and the spreading out of projects activities in space and time (years), the impacts are not expected to be cumulatively significant.

Karst

Field surveys conducted for this project have not found any sinkholes, limestone caves or other karst features. No karst features are known in the project area. Alternative 1 and 2 would have no effect on karst. The No Action Alternative and the Proposed Action Alternative would not likely affect karst resources.

References

Collins, T. K. (2008). Debris flows caused by failure of fill slopes: Early detection, warning, and loss prevention. Landslides, 5, 107–119.

Hubbard, D. A., Jr., 2001, Selected karst features of the southern Valley and Ridge province, Virginia: Virginia Division of Mineral Resources, Publication 167, one sheet.

Miller, R.L., 1965, Geologic map of the Big Stone Gap quadrangle, Virginia: U.S. Geological Survey, Geologic Quadrangle Map GQ-424, scale 1:24,000.

Miller, R.L., and Roen, J.B., 1971, Geologic map of the Keokee quadrangle, Virginia-Kentucky: U.S. Geological Survey, Geologic Quadrangle Map GQ-851, scale 1:24,000.

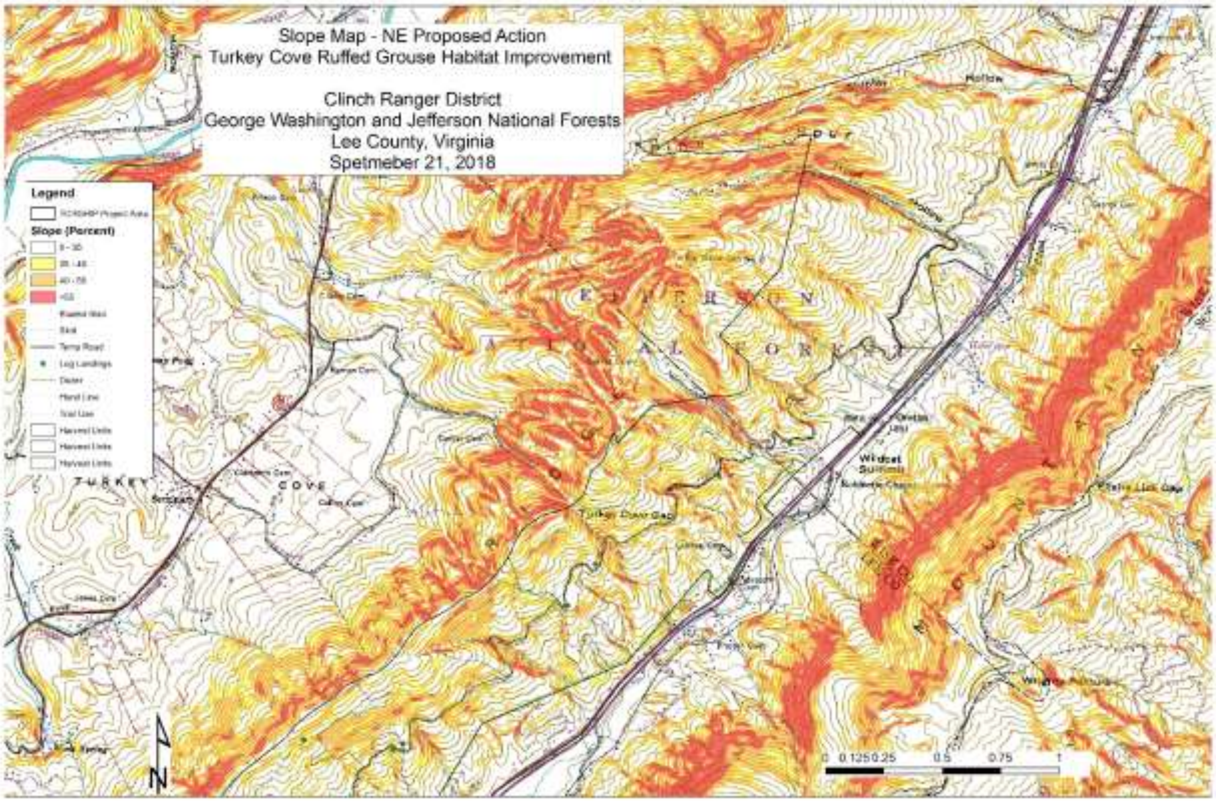
Outerbridge, W.F., 1982, Landslides and Related Features of the Big Stone Gap, VA. Quadrangle: U.S. Geological Survey, Open-File Report OF-82-422 (G-10), scale 1:24,000.

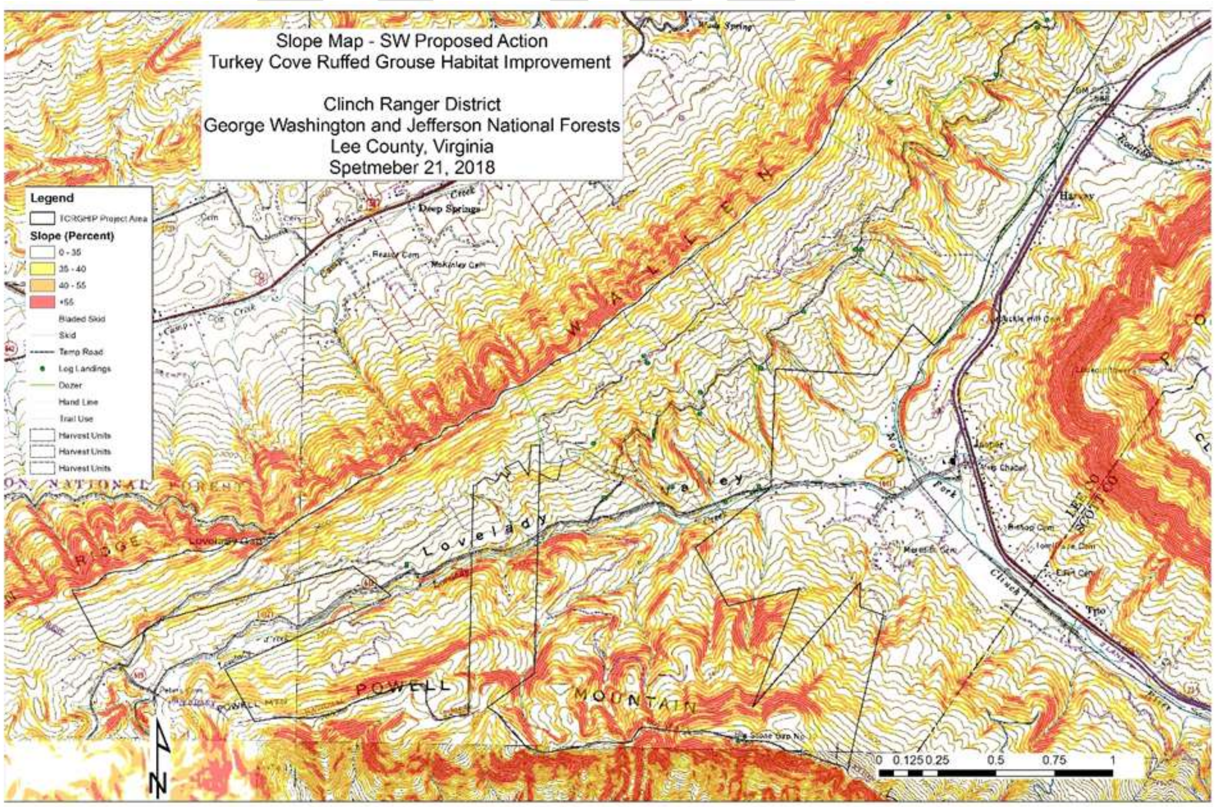
Outerbridge, W.F., 1982, Landslides and Related Features of the Keokee, VA. - KY. Quadrangle: U.S. Geological Survey, Open-File Report OF-82-422 (G-9), scale 1:24,000.

Virginia Division of Geology and Mineral Resources, 2018, Interactive Geologic Map. Accessed September 20, 2018. https://www.dmme.virginia.gov/webmaps/DGMR/

Weary, D.J., and Doctor, D.H., 2014, Karst in the United States: A digital map compilation and database: U.S. Geological Survey Open-File Report 2014–1156, 23 p. http://dx.doi.org/10.3133/ofr20141156

Wooten, R.M., Witt, A.C., Miniat, C.F., Hales, T.C., Aldred, J.A., 2015, Frequency and Magnitude of Selected Historical Landslide Events in the Southern Appalachian Highlands of North Carolina and Virginia: Relationships to Rainfall, Geological and Ecohydrological Controls, and Effects, In: Natural Disturbances and Historic Range of Variation: Type, Frequency, Severity, and Post-disturbance Structure in Central Hardwood Forests USA (Greenberg, C.H. and Collins, B.S. eds), pp 203-262.


Slope Map - NE Proposed Action
Turkey Cove Ruffed Grouse Habitat Improvement
Clinch Ranger District
George Washington and Jefferson National Forests
Lee County, Virginia
Spetmeber 21, 2018
Legend
Slope (Percent)
0 0.125 0.25 0.5 0.75 1


Slope Map - SW Proposed Action
Turkey Cove Ruffed Grouse Habitat Improvement
Clinch Ranger District
George Washington and Jefferson National Forests
Lee County, Virginia
Spetmeber 21, 2018
Legend
TCRGHIP Project Area
Slope (Percent)
0 - 35
35 - 40
40 - 55
+55
Bladed Skid
Skid
Temp Road
Log Landings
Dozer
Hand Line
Trail Use
Harvest Units
Harvest Units
Harvest Units
0 0.125 0.25 0.5 0.75 1